PUSH BACK STORAGE RACK SYSTEM

This application claims the benefit of U.S. Provisional Application No. 60/237,797 filed on October 4, 2000, which is incorporated herein by reference.

Background

The present invention is directed to the field of storage rack systems. More particularly, the present invention is directed to a push back type of storage rack system for storing a plurality of loads in which multiple loads may be stored in a single storage lane.

Push back storage racks normally comprise an assembly of shelves and vertical uprights for supporting loads placed on tracks or other base members in one or more storage lanes. Each storage lane has one loading position capable of storing one load. One or more vertically spaced push back carts are positioned in the loading position. Each cart is capable of receiving one load, being pushed toward the back of the lane by the next load, and sliding over the top of one another when unloaded. Such systems normally have their tracks in each lane tilted toward the loading position so that the force of gravity causes the next cart in line to return to the loading position when a load occupying the position is removed.

When adding a load to a particular lane, the operator pushes the added load against a previously stored load occupying the lane's loading position. This forces the cart under the previously stored load further up the lane and out of the loading position, thereby making room for the load being added. If additional carts are in the loading position, the operator then positions the load on the next available cart. If all the carts have been pushed out of the loading position, the added load fills the lane to capacity, and the operator places the added load directly onto the tracks or base member of the lane itself.

Previous push back storage systems have also included designs which permit unloaded carts to automatically slide into the loading position of their respective storage lanes to receive loads. Most designs allow the empty carts to simultaneously occupy the same loading position by incorporating either a nesting or telescoping cart arrangement.

In previous nesting designs, higher level carts retract or nest within the horizontal dimensions of each next lower level cart. Such designs have been limited in both the number of carts that can be included in a single system and in the relative strength of each cart since the designs typically require the use of a single pair of track members and since the required horizontal clearance for successive carts prevents the inclusion of structural cross members. Due to the resulting limitations on the amounts of available space in such designs, these characteristics have also severely limited the number of carts that can be used and thus the number of loads that can be stored in a single lane. Additionally, smaller and weaker components may be used which substantially reduce the load-bearing capabilities of the system. In addition to substantially limiting the system's load-bearing capacity, smaller components, such as cart wheels, also tend to increase the amount of external force necessary to operate such systems. This ultimately leads to the need for more steeply sloped track inclines, which are undesirable, and normally increases the amount of wear and potential damage to the system, loading equipment, and stored loads.

In previous telescoping designs, individual carts have been vertically spaced so that each higher level cart merely slides over the top of the next adjacent lower level cart. Previous telescoping designs have been severely limited in the number of carts that can be incorporated in a single lane due to the vertical space needed to include a rigid support piece across the width of each cart. Such cross pieces tend to make the additional vertical height required for each cart too great to incorporate many

carts into a single lane. In contrast, eliminating such pieces tends to severely reduce the load capacity of each individual cart.

Previous telescoping designs have also been limited by the fact that most use only a single pair of track members with one or more support surfaces upon which the wheels of the various carts ride. As with nesting designs, this characteristic of most telescoping designs has severely limited the number of carts and thus the number of loads which can be included in a single lane, while posing the same problems of wear, potential damage to the system, equipment, and loads. In the few instances where multiple pairs of tracks have been incorporated, some portions of the various support surfaces have been left unused. As a result, both space and load-bearing capacities have been wasted in such previous systems, reducing their cost-effectiveness and versatility.

In some previous designs, push plates have been positioned at the trailing edge of the lowest or last-loaded cart to assure that an operator maintains proper pallet clearance during loading and to indicate, when it is not visible to the operator, that a particular lane is filled to capacity. It has been observed from time to time that pallets on which loads are stored drag against an adjacent surface of the push plate, causing damage to the pallets during loading and unloading.

Many of the previous designs of push back rack systems have also been plagued by the problem of outward bowing of the beam adjacent each lane's loading position. The problem is associated with the repeated forces exerted by a system's carts as they automatically return to their respective loading positions. As each cart repeatedly returns to this position, stopping forces are exerted upon the adjacent beam member which, over time, tends to bend or warp outwardly and away from the storage lane in which it is mounted. This is an additional problem which previous push back storage systems have yet been unsuccessful in resolving.

Summary

The present invention is a push back storage rack system for storing a plurality of pallet loads in which multiple loads may be stored in a single storage lane. Each lane contains at least two wheeled carts, each cart being capable of receiving and storing multiple pallet loads. The carts are vertically spaced so that they can freely slide underneath each other when unloaded. Beginning with the first or lowest level cart in the system, each successively higher cart is also wider and longer than the cart immediately beneath it. The carts are positioned on at least one but potentially two pairs of rectangular tracks or tubes, each tube being capable of supporting two or four individual carts, depending on how the carts are constructed and installed on the tubes. The tubes are mounted on an incline away from a loading end of each lane so that when loads are placed on and removed from a lane, the carts are biased toward the loading end of the lane by the force of gravity. Each tube has a single, planar upper support surface which has inside and outside edges. The wheels of each cart ride only on either the inside or outside edges of the tubes on which they are mounted, allowing more than one vertically spaced cart to occupy the same tube. A support beam is located at the loading end of each lane.

The end of each cart closest to the loading end of the lane in which the cart is mounted is the trailing end of the cart and the opposite end of each cart is the leading end. When the carts are unloaded and positioned in a loading position at the loading end, the trailing end of the lowest cart rests flush against the adjacent support beam. The carts are constructed so that each successively higher cart is slightly longer than the next cart below. Following the lowest level cart of the system, a structural member at about the leading end of each successively higher cart contacts a structural member at about the leading end of the cart immediately below it when returning to the loading position. This transfers the impact force of each load to the trailing end of the lowest cart, thereby

minimizing curling and excessive warping of the beam. Additionally, tension bars positioned between approximately the middle of the structural beam and other structural members of the rack system also serve to significantly reduce the bowing or warping effect to a minimum. A push plate mounted on the trailing end of the lowest cart is offset from vertical, away from this cart, to prevent dragging on the end of pallets and subsequent damage to individual pallets and loads.

In the preferred embodiment of this invention the structural member at the leading end of each cart is an angle plate having two sections at a 90° angle to one another. The fact that each successively higher cart is slightly longer than the next lower cart enables the end of each cart's horizontal section to contact the vertical section of the cart beneath it so that the carts stack above one another without greatly adding to the vertical height needed for each additional cart. Additionally, the vertical section of each leading angle piece provides rigidity for supporting heavy loads.

At the trailing edge of each cart, relatively thin loading plates can also stack without adding a great deal of vertical height to the system. To maintain rigidity, vertical stiffeners extend downward below each loading plate, substantially along the width of the cart. For each successively higher cart, the stiffener is placed slightly further away from the cart's trailing edge than the stiffener on the cart immediately beneath it, allowing the stiffeners to remain clear of each other when the carts are stacked in the loading position.

In an optional embodiment of the design, up to four additional carts may be included in the system. In this embodiment, the wheels of every second adjacently spaced pair of carts travel along the same edges of a particular pair of tubes, the two adjacent carts being interlocked by having the trailing wheels of one cart positioned between the leading and trailing wheels of the other. Thus, it becomes possible to position twice the number of carts on the same number of tubes without consuming substantial additional space.

The narrow stacking characteristics inherent in this novel design enable as many as nine loads to be positioned in a single storage lane. Each individual cart, up to a maximum of eight, can store one load. A ninth load can then be positioned directly on the storage lane's tubes after all of the carts are loaded. For applications requiring the storage of five or fewer loads per lane, minor modifications to the design enable the system to be even more compact. The use of multiple rails and interlocked carts enable heavier components, such as wider and higher capacity wheels, to be incorporated into the design. Such components require less external force for operation, allowing for a gentler inclined slope for the inclined tubes and a higher load capacity for the individual carts, thereby reducing the amount of wear and potential damage experienced by the system, stored loads, and loading equipment.

Other embodiments of the invention include mechanisms for preventing accidental lifting or disengagement from the tubes without increasing the sizes of successive carts. In one embodiment, wheels from the one or two carts positioned on the inside edges of the outer tubes are positioned to extend toward the carts' middle portions in order to provide clearance for vertical anti-lift extensions that reach downwardly from the carts on the outside edges of the inside tubes. The inner carts, in turn, have horizontal flanges which prevent vertical movement of the outer carts. In another embodiment, the system's lowest and highest carts dispose vertical extensions which lock the carts to stop flanges located below the inside edges of the inside tubes and below the outside edges of the outside tubes, respectively. A series of interlocked flanges positioned between the individual carts then works as an integrated mechanism to prevent vertical movement of the carts. Both of these embodiments save additional space and enable the incremental spacing of successive carts to remain substantially constant regardless of the particular tube or edge on which the cart's wheels are positioned.

Various other features, advantages, and characteristics of the present invention will become apparent to one of ordinary skill in the art while reading the following specification. This invention does not reside in any one of the features of the push back rack system disclosed below. Rather, this invention is distinguished from the prior art by its particular combination of features which are disclosed. Important features of this invention have been described below and shown in the drawings to illustrate the best mode contemplated to date for carrying out this invention.

Those skilled in the art will realize that this invention is capable of embodiments which are different from those shown and described below and that the details of the structure of this push back rack system can be changed in various manners without departing from the scope of this invention. Accordingly, the drawings and description below are to be regarded as illustrative in nature and are not to restrict the scope of this invention. The claims are to be regarded as including such equivalent push back rack systems as do not depart from the spirit and scope of the invention.

Brief Description of the Drawings

For a more complete understanding and appreciation of this invention and many of its advantages, reference should be made to the following, detailed description taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a perspective view of a push back storage rack system according to the invention illustrating the relative positioning of carts and loads in multiple independently operating lanes positioned throughout the system;

FIG. 2 is a side view of the push back storage rack system of FIG. 1, further demonstrating the relative inclines of the individual vertically spaced storage lanes;

FIG. 3 is a perspective view of an independent push back storage system as would typically occupy one cart lane having four individual and unloaded carts as if positioned at the loading end of a particular lane;

FIG. 4 is a front view of two adjacent tubes from the push back storage system of FIG. 3 depicting the respective wheels, angle plates, and hold-down cart components positioned adjacent to the depicted tubes;

FIG. 5 is an exploded view of the push back storage system of FIG. 3 depicting the structural details of the individual carts of the system;

FIG. 6 is perspective view of an independent push back storage system as would typically occupy one cart lane having five individual and unloaded carts as if positioned at the loading end of a particular lane;

FIG. 7 is a front view of two adjacent tubes from the push back storage system of FIG. 6 depicting the respective wheels, angle plates, and hold-down cart components positioned adjacent to the depicted tubes;

FIG. 8 is an exploded view of the push back storage system of FIG. 6 depicting the structural details of the individual carts of the system;

FIG. 9 is a side view of the trailing edges of the carts of the push back storage system of FIG. 3 depicting the loading plates and stiffeners of the individual carts.

FIG. 10 is a side view of the leading edges of the carts of the push back storage system of FIG. 3 depicting the leading angle plates of the individual carts; and

FIG. 11 is a side view of an alternate embodiment of the leading edges of the carts of the push back storage system that is the subject of the invention depicting the leading angle plates of the individual carts.

Detailed Description of the Preferred Embodiments

Referring to the drawings, identical reference numerals and letters designate the same or corresponding parts throughout the several figures shown in the drawings.

FIG. 1 shows a push back storage rack system of the type that is the subject matter of the invention. The system is based on a storage rack assembly **20** comprising a number of interconnected, vertical uprights **22** and horizontal beams **24**. Side horizontals **26** and diagonal cross pieces **28** may also extend between the vertical uprights **22** to make up rack cells **30** along the depth of the rack system. Two separate cart lanes **34**, each having a load end **32**, are positioned along the lengths of the beams **24**. To prevent the beams **24** from bowing outwardly and away from the rest of the system due to the stresses exerted on the beams **24** during operation, one or more diagonal tension bars **36** may also be positioned between about the center of one or more of the beams **24** and one or more vertical uprights **22** under the cart lanes **34**. Alternatively, diagonal tension bars may be fastened between about the center of a beam **24** and a beam at the end of the first rack cell **30** that is connected to the uprights **22** at the end of that rack cell. As shown in FIG. 1, a separate push back assembly occupies each individual lane **34**.

Referring briefly to FIG. 2 along with FIG. 1, the storage rack assembly **20** is capable of storing multiple loads **38** in each cart lane **34**. Each load **38** is placed on a separate cart that rides on a set of tracks which are mounted at a slight incline away from the loading end **32** of the cart lane **34**. First, second, third, and fourth carts **41**, **42**, **43**, and **44** are shown in an extended position in three vertically stacked cart lanes **34** on tracks which comprise a pair of tubes **50** that extend along their respective cart lane **34**.

The four-cart configuration of the carts **41-44** is depicted in its unloaded position in FIGS. 3 and 4. The pair of tubes **50** includes a pair of parallel inside tubes **52** and a pair of parallel outside tubes **54**. Each of the inside tubes **52** has a single upper support surface **56** having an inside edge **58** and an outside edge **60**. In this embodiment, each outside tube **54** is substantially similar to each inside tube **52**, with the outside tubes **54** also each having a single upper support surface **55**, an inside edge **57** and an outside edge **59**.

As shown in FIG. 5, the first cart **41** has a pair of parallel side angle plates **62** with each angle plate **62** having a substantially horizontally planar surface **64** and a substantially vertically planar surface **66**. The horizontal surface **64** extends outwardly from the vertical surface **66** and away from the middle of the first cart **41**. Each vertical surface **66** has at least two cart wheels **68** mounted on it which are positioned to ride directly on the inside edge **58** of the upper support surface **56** of the inside tube **52** on which they are mounted. The first cart's wheels **68** also extend outwardly and away from the middle of the first cart **41**. Each wheel **68** has a flanged edge **70** for engaging the inside edges **58** of the tubes **52** and for properly positioning the wheels **68**.

Each cart has a leading end which is the end that is farthest from the loading end **32** of the cart lane **34** in which it is located and has a trailing end which is farthest from the loading end **32**. Referring again to FIG. 5, a structural member shown as a leading angle plate **72** extends between the side angle plates **62** at the leading end of the first cart **41**. Like the side angle plates **62**, the leading angle plate **72** has a substantially vertically planar surface **74** and a substantially horizontally planar surface **76** forming the cart's leading end **78**. A trailing connecting tube **80** also extends between the side angle plates **62** forming a trailing end **82** of the cart **41**.

A push plate **81** is mounted at the cart's trailing end **82**. Though having a substantially vertically planar lower surface **85**, the push plate **81** has an upper portion **83** that is bent slightly, for example five degrees away from vertical, leaning away from the first cart **41**. The functional advantages of this feature are examined more closely below.

Referring back to FIG. 4, the second cart **42** rides on the outside edges **60** of the upper support surfaces **56** of the inside tubes **52**. The second cart **42** has a pair of parallel side angle plates **84** with each angle plate **84** having a substantially vertically planar surface **86** and a substantially horizontally planar surface **88**. The horizontal surface **88** extends inwardly from the vertical surface **86** and toward the middle of the second cart **42**. Each vertical surface **86** also has at least two cart wheels **90** mounted on it which are positioned to ride directly on the outside edge **60** of the inside tube **52** on which they are mounted. The second cart's wheels **90** also extend inwardly and toward the middle of the second cart **42**. Each wheel **90** has a flanged edge **92** for properly positioning the wheels **90** and for engaging the outside edges **60** of the tubes **52**.

As best shown in FIG. 5, a structural member shown as a leading angle plate **94** extends between the side angle plates **84** of the second cart **42**. The leading angle plate **94** also has a substantially vertically planar surface **96** and a substantially horizontally planar surface **98** forming the cart's leading end **99**. A trailing loading plate **100** extends between the side angle plates **84** forming the trailing end of the second cart **102**.

Referring again to FIG. 4, the third cart **43** rides on the inside edges **57** of the upper support surfaces **55** of the outside tubes **54**. The third cart **43** has a pair of parallel side angle plates **104** with each angle plate **104** having a substantially vertically planar surface **106** and a substantially horizontally planar surface **108**. The horizontal surface **108** extends inwardly from the vertical

surface **106** and toward the middle of the third cart **43**. Each vertical surface **106** also has at least two cart wheels **110** mounted on it which are positioned to ride directly on the inside edge **52** of their respective outside tube **54**. The third cart's wheels **110** also extend inwardly and toward the middle of the third cart **43**. Each wheel **110** has a flanged edge **112** for engaging the inside edges **57** of the tubes **54** and for properly positioning the wheels **110** on these tubes.

Again as best shown in FIG. 5, a structural member shown as a leading angle plate **114** extends between the side angle plates **104** of the third cart **43**. The leading angle plate **114** also has a substantially vertically planar first surface **116** and a substantially horizontally planar second surface **118** forming the cart's leading end **119**. Like the second cart **42** and unlike the first cart **41**, a trailing loading plate **120** extends between the side angle plates **104** forming the trailing end of the third cart **122**.

Referring once again to FIG. 4, the fourth cart **44** rides on the outside edges **59** of the upper support surfaces **55** of the outside tubes **54**. The fourth cart **44** has a pair of parallel side angle plates **124** with each angle plate **124** having a substantially vertically planar surface **126** and a substantially horizontally planar surface **128**. The horizontal surface **128** extends inwardly from the vertical surface **126** and toward the middle of the fourth cart **44**. Each vertical surface **126** also has at least two cart wheels **130** mounted on it which are positioned to ride directly on the outside edge **59** of their respective outside tube **54**. The fourth cart's wheels **130** also extend inwardly and toward the middle of the fourth cart **44**. Each wheel **130** has a flanged edge **132** for engaging the outside edges **59** of the tubes **54** and for properly positioning the wheels **130** on these tubes.

Again as best shown in FIG. 5, a structural member shown as a leading angle plate **134** extends between side angle plates **136** of the fourth cart **44**. The leading angle plate **134** also has a

substantially vertically planar surface **138** and a substantially horizontally planar surface **140** forming the cart's leading end **142**. Like the second and third carts **42** and **43,** and unlike the first cart **41**, a trailing loading plate **144** extends between the side angle plates **136** forming the trailing end **146** of the fourth cart **44**.

In operation, carts **41-44**, being unloaded, remain positioned over top of one another at the loading end **32** of their lane as shown in FIG. 3. The fourth cart **44**, being the highest cart in the system, stands available to receive a load. Referring to FIG. 1, the operator, using appropriate lifting equipment, lifts and carries a load **38** over the beam **24** at the loading end **32** of the selected lane **34**. The load **38** is then lowered into position on the fourth cart **44**.

While positioning the load **38**, the operator carefully raises the load **38** to a sufficient height so that the load **38** has adequate vertical clearance to avoid contact with the push plate **81**. As noted above, the push plate **81** has an upper portion **83** that is bent slightly away from the first cart **42**. As the operator lowers the load **38** into position, the slight bend of the push plate's upper portion **83** allows a pallet carrying the load **38** to contact the inside planar surface of the upper portion **83** rather than contact the push plate **81** along its top edge **148**. This reduces the likelihood of damage to the pallet or to the load **38** that could potentially result from the heavy downward force of the load **38** being exerted against the top edge **148**. Additionally, when a load **38** is removed, the slight bend of the upper portion **83** of the push plate **81** reduces friction between the pallet and the push plate, reducing the potential for damage to the pallet.

After positioning a load **38** on the fourth cart **44**, the operator positions an additional load **38** by lifting the additional load with appropriate lifting equipment and carrying the load **38** over the selected lane's beam **24**. As it is carried forward, the load **38** contacts the previously positioned load

38, pushing the load **38** and its supporting fourth cart **44** further up the inclined outer tubes **54**. The fourth cart **44** slides away from the loading end **32** of the cart lane **34**, making the third cart **43** available to receive the next load **38**. This load is then lowered into the cart lane **34** at the lane's loading end **32**.

Subsequent loads **38** are added to the cart lane **34** in a similar manner. The operator uses each subsequent load **38** to push the previous load **38** and its respective cart further up the inclined tubes **52** and **54**, thereby making the next lower cart available to receive and store the subsequent load **38**. In an embodiment of the design using four carts, up to five loads may be positioned at one time in the same cart lane **34**. After the first cart **41** has been loaded with a fourth load, the operator can add a fifth load by pushing the fifth load against the load **38** previously positioned on the fourth cart **41**. Thus the first cart **41** and the load on it slide further up the inclined tubes **52**. The operator then lowers the fifth load directly on to the tubes **52** and **54**, filling the cart lane **34** to capacity. The push plate **81**, mounted on the first cart **41**, then moves along with the first cart **41** away from the loading end **32** of the cart lane **34** where it is blocked from view by the fifth load. Since the push plate **81** is not visible, the operator knows the cart lane **34** is fully loaded.

During the unloading of the cart lane **34**, individual loads **38** are removed from the tubes or from their respective carts, allowing the carts **41-44** to slide back down along the tubes **52** and **54** toward the loading end **32** under the force of gravity. In a four-cart system, during removal of the fifth load **38** from the tubes **52** and **54**, the fourth cart **41** begins to slide back down the tubes and return to the loading end **32** of the cart lane **34**. Once the fourth cart **41** reaches the loading end **32**, the lower surface **85** of the push plate **81**, being mounted at the first cart's trailing end **82**, comes into contact with the beam **24** extending across the lane's loading end **32**. When the operator removes the next load **38** positioned on the first cart **41**, the second cart **42** begins to slide back down the tubes

and over the top of the first cart **41** into the loading end **32** of the cart lane **34**. However, unlike the first cart **41**, the trailing edge **102** of the second cart **42** does not make contact with the beam **24**.

FIG. 10 is a side sectional view of the relative positioning of the leading angle plates **72**, **94**, **114**, and **134** of the carts **41, 42, 43** and **44**, respectively when all the carts are at the loading end **32** of their respective lane **34**. Consider the second cart **42** returning to the loading position **32** after the unloading of the first cart **41**. According to this invention, the vertical surface **96** of the leading angle plate **94** of the second cart **42** contacts the end of the horizontal surface **76** of the leading angle plate **72** of the first cart **41**. Referring to FIGS. 3 and 4 along with FIG. 10, the contact between these two surfaces of the structural members at the leading ends of the carts **41** and **42** restricts subsequent movement of the second cart **42** down the inclined tubes **52** on which it is mounted. Thus, loading end impact between the various carts occurs at the carts' leading ends rather than at the carts' trailing ends. This impact relationship is repeated between the angle plates **114** of cart **43** and **44** of cart **42** and between angle plates **134** of cart **44** and **114** of cart **43**.

FIG. 9 is a side view of the trailing ends of the various carts in a typical 5-deep system made in accordance with this invention when the trailing connecting tube **80** of the first cart **41** and the loading plates **100**, **120**, and **144** of the second, third and fourth carts **42-44** are all positioned at the loading end of the cart lane **32**. That is, all of the leading ends of the carts **41-44** have contacted and restricted the movement of each adjacently higher cart as shown in FIG. 10, and the loading plates of the carts **41-44** do not contact one another and do not transmit force between loads.

In FIG. 9 according to another aspect of this invention, stiffener angle plates **150** and **152** have been added to the bottoms of the loading plates **120** and **144**, respectively, and a stiffener flange plate **153** has been added to the bottom of the loading plate **100**, respectively. These added stiffener plates **150, 152** and **153** serve to give additional cross member strength to their respective loading

plates **100**, **120**, and **144**, thereby adding additional cross strength to each plate's respective carts **42-44**, enabling each cart to bear heavier loads. These stiffener plates **150, 152** and **153** are staggered beneath the carrying surfaces of the carts to enable the carts to have a low profile, while increasing their load capacity.

In accordance with the above, FIG. 9 shows the gap **154** between stiffener plate **152** and loading plate **120**, gap **156** between stiffener plate **150** and loading plate **100** and gap **158** between stiffener **153** and connecting tube **80** after all the carts **41-44** have made contact through their leading angle plates **72, 94, 114** and **134**, respectively, as shown in FIG. 10. Moreover, contact with the first cart's push plate **81** is not made by any of the second, third, or fourth carts **42-44** due to the tilt of the upper portion **83** of the push plate **81**. As a result, contact of every higher cart **42-44** with the beam **24** of the cart lane **32** is made only indirectly through the first cart **41**. Consequently, all impact forces exerted on the beam **24** are exerted indirectly only through the lower surface **85** of the push plate **81**.

Referring now to FIGS. 3 and 4, the side angle plates **62**, **84**, and **124** of the first, second, and fourth carts **41**, **42**, and **44** each have a number of downward reaching retaining hooks **160**, **162**, and **164**, with each safety hook **160**, **162**, and **164** having a horizontal locking surface **166**, **168**, and **170**, all respectively positioned. The horizontal locking surfaces **166**, **168**, and **170** each extend under flanges **172**, **174**, and **176** that are adjacent their respective carts. Each of the flanges **172**, **174**, and **176** are positioned below the respective tube edges **58**, **60**, and **59** under which their respective carts' wheels **68**, **90**, and **130** roll and extend along the length of their respective tubes **52** and **56**. In the event of a vertical movement, such as an accidental lifting by the operator's loading equipment of one or more of the first, second, or fourth carts **41**, **42**, and **44**,, the resulting upward movement of the hooks **160**, **162**, and **164** causes the horizontal locking surfaces **166**, **168**, and **170** to contact with

each hook's respective flange **172**, **174**, and **176**, restricting further cart movement and preventing disengagement of the carts **41**, **42**, and **44** from their proper positioning.

In order to maintain approximate incremental sizing of the carts **41-44**, it is necessary to omit the positioning of hooks and flange assemblies to restrict vertical movement of the third cart **43**. As described above, the second horizontal surfaces **88** of the third cart's side angle plates **84** extend inwardly from the angle plates' vertical surfaces **86** and toward the middle of the third cart **43**. This permits extension flanges **180** to extend from the vertical surfaces **86** of the second cart's side angle plates **84** over the adjacently positioned wheels **110** of the third cart **43** to guard against the possibility of accidental disengagement. This also permits incremental cart spacing without further widening the distance between each adjacent inside tube **52** and outside tube **54**. The extension flanges **180** are substantially horizontally planar in shape and extend approximately three-quarters of the outside length of the second cart **42**, being centered lengthwise in this dimension on the angle plates **84**. In the event of vertical movement of the third cart **42**, the third cart's wheels **110** contact the extension flanges **180**, which, being connected to the second cart **42**, are restricted in upward movement by the second cart's hooks **162** and flanges **174**. This arrangement thus prevents accidental disengagement of the third cart **43** without requiring the added space of separate hooks proximate to the directional line of travel of the third cart's wheels **110**.

In an optional embodiment of the design, up to four additional carts may be placed in a single storage lane without increasing the number of tubes needed for the storage system. Referring to FIGS. 6 and 7, this embodiment incorporates an inside and an outside pair of inclined tubes **182** and **184**. The inside pair of tubes **182** has an upper support surface **186** having an inside edge **188** and an outside edge **190**. The outside pair of tubes **184** also each include an upper support surface **192** divided into inside and outside edges **194** and **196**. Unlike the previously-described embodiment for

systems of up to four carts, the upper support surfaces **192** of the outside tubes **184** are vertically spaced above the upper support surfaces **192** of the inside tubes **182** rather than all support surfaces being at an approximately even level.

As is best understood comparing FIG. 6 to FIG. 7, the first cart **210** includes side angle plates **212** having vertically planar surfaces **214**, each vertically planar surface **214** disposing leading and trailing wheels **213** that extend outwardly and away from the middle of the first cart **210**. The first cart's wheels **213** are positioned to roll on the inside surfaces **188** of the inside tubes **182**. The second cart **220** also includes angle plates **222** having vertically planar surfaces **224**, each vertically planar surface **224** disposing leading and trailing wheels **223** that extend inwardly and toward the middle of the second cart **220**. The second cart's wheels **223** are also positioned to ride on the inside surfaces **188** of the inside tubes **182**. In order to allow both the wheels **213** and **223** of the first and second carts **210** and **220** to run on the same inside edges **188** of the inside tubes **182**, the trailing wheels **213** of the first cart **210** are positioned between the leading and trailing wheels **223** of the second cart **220**, thereby interlocking the wheels **213** and **223** and allowing for relative movement along the same directional line defined by the inside tubes' inside edges **188**.

Again, as is best understood comparing FIG. 6 to FIG. 7, the third cart **230** includes side angle plates **232** having vertically planar surfaces **234**, each vertically planar surface **234** disposing leading and trailing wheels **233** that extend inward and toward the middle of the third cart **230**. The third cart's wheels **233** are positioned to roll on the outside surfaces **190** of the inside tubes **182**. The fourth cart **240** also includes angle plates **242** having vertically planar surfaces **244**, each vertically planar surface **244** disposing leading and trailing wheels **243** that extend inwardly and toward the middle of the fourth cart **240**. The fourth cart's wheels **243** are also positioned to ride on the outside surfaces **190** of the inside tubes **182**. In order to allow both the wheels **233** and **243** of the third and

fourth carts **230** and **240** to run on the same outside edges **190** of the inside tubes **182**, the trailing wheels **233** of the third cart **230** are positioned between the leading and trailing wheels **243** of the fourth cart **240**, thereby interlocking the wheels **233** and **243** and allowing for relative movement along the same directional line defined by the inside tubes' outside edges **190**.

This relative arrangement pattern repeats itself for the carts **250**, **260**, **270** and **280** positioned on the outside pair of tubes. The fifth cart **250** includes side angle plates **252** having vertically planar surfaces **254**, each vertically planar surface **254** disposing leading and trailing wheels **253** that extend outward and away from the middle of the fifth cart **250**. The fifth cart's wheels **253** are positioned to roll on the inside surfaces **194** of the outside tubes **184**. The sixth cart **260** also includes angle plates **262** having vertically planar surfaces **264**, each vertically planar surface **264** disposing leading and trailing wheels **263** that extend inwardly and toward the middle of the sixth cart **260**. The sixth cart's wheels **263** are also positioned to ride on the inside surfaces **194** of the outside tubes **184**. In order to allow both the wheels **253** and **263** of the fifth and sixth carts **250** and **260** to run on the same inside edges **194** of the outside tubes **184**, the trailing wheels **253** of the fifth cart **250** are positioned between the leading and trailing wheels **263** of the sixth cart **260**, thereby interlocking the wheels **253** and **263** and allowing for relative movement along the same directional line defined by the outside tubes' inside edges **194**.

The two highest carts are similarly interlocked. The seventh cart **270** includes side angle plates **272** having vertically planar surfaces **274**, each vertically planar surface **274** disposing leading and trailing wheels **273** that extend outward and away from the middle of the seventh cart **270**. The seventh cart's wheels **273** are positioned to roll on the outside surfaces **196** of the outside tubes **184**. The eighth cart **280** also includes angle plates **282** having vertically planar surfaces **284**, each vertically planar surface **284** disposing leading and trailing wheels **283** that extend inwardly and

toward the middle of the eighth cart **280**. The eighth cart's wheels **283** are also positioned to ride on the outside surfaces **196** of the outside tubes **184**. In order to allow both the wheels **273** and **283** of the seventh and eighth carts **270** and **280** to run on the same outside edges **196** of the outside tubes **196**, the trailing wheels **273** of the seventh cart **270** are positioned between the leading and trailing wheels **283** of the eighth cart **280**, thereby interlocking the wheels **273** and **283** and allowing for relative movement along the same directional line defined by the outside tubes' outside edges **196**.

Due to the greater number of carts being present in a similarly confined space, this later cart-and-tube arrangement for systems of up to eight carts is inherently more crowded than are embodiments for up to four carts only. Consequently, a different system must be incorporated to prevent accidental disengagement due to accidental cart lifting. In FIGS. 6 and 7, downward reaching retaining hooks **286** and **288** extend from the side angle plates **212** and **282** of the first cart **210** and eighth cart **280**, each disposing horizontal locking surfaces **240** and **242** which extend under adjacent flanges **244** and **246**. The flanges **244** and **246** are positioned along the lengths of the inside tubes **182** below the tubes' inside edges **188** and along the outside tubes **184** below the tubes' outside edges **196**. In the event of vertical movement of the first or eighth carts **210** or **280**, the horizontal locking surfaces **240** and **242** of the retaining hooks **286** and **288** lock against the flanges **244** and **246**, restricting the carts' movement and preventing accidental tube disengagement.

Focusing now on FIG. 7, horizontally planar top flanges **290** are positioned on the side angle plates **214** of the first cart **210** extending outwardly from the middle of the first cart **210** and over a lower angle flange **302** mounted on the side angle plate **222** of the second cart **220**. The lower angle flanges **302** are substantially horizontally planar, extending approximately three-quarters the length of their respective second cart **220** on the cart's side angle plates **220** and approximately centered on the side angle plates' vertical surfaces **224** in the horizontal dimension. In the event of vertical

movement of the second cart **220**, the second cart's lower angle flanges **302** collide with the planar top flanges **290**, which, as part of the first cart **210**, are restricted in movement by the retaining hook **286**. Thus, the contact between the second cart's lower angle flanges **302** and planar top flanges **290** restricts further upward movement of the second cart **220**. To restrict higher level carts, the second through seventh carts **220**, **230**, **240**, **250**, **260**, and **270** each dispose top angle flanges **300** on their respective side angle plates **222**, **232**, **242**, **252**, **262**, and **272** which extend outwardly and away from the middles of their respective carts. The top angle flanges **300** of each adjacently lower cart are positioned to contact the lower top flanges **302** and thereby restrict vertical cart movement in the event of accidental lifting of one or more carts. Thus, each second through seventh cart **222**, **232**, **242**, **252**, **262**, and **272** is ultimately restricted indirectly by the retainer hook **286** of the first cart **210** via the interlocked system of planar and angle flanges **290**, **300**, and **302**. Vertical movement of the eighth cart **284** is restricted by the presence of its own retainer hooks **288** locking against flanges **246**.

Those skilled in the art will recognize that the various features of this invention described above can be used in various combinations with other elements without departing from the scope of the invention. Thus, the appended claims are intended to be interpreted to cover such equivalent push back rack systems which do not depart from the spirit and scope of the invention.